Cross-Tenant Trust Models in Cloud Computing

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OUTLINE

- Introduction
- Background and Motivation
- Cross-Tenant Trust Model (CTTM)
  - Tenant Trust Relations
  - Formalized Model
  - Role-Based CTTM (RB-CTTM)
- Related Work
- Conclusion and Discussion

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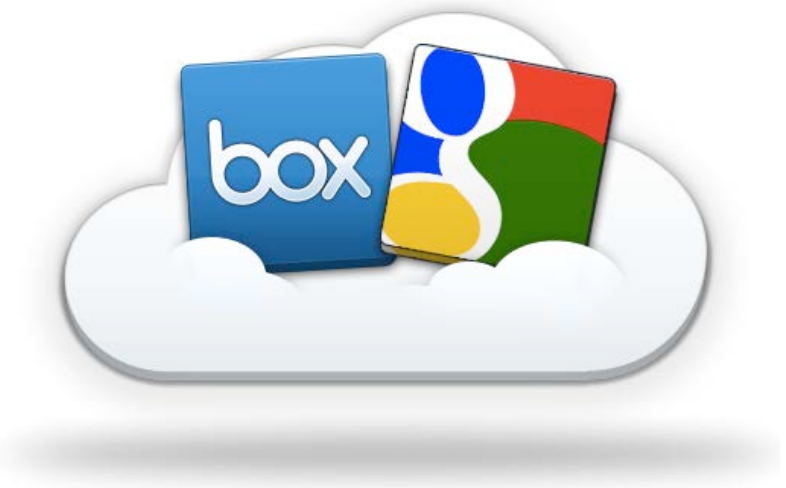
Cloud Computing

- Shared infrastructure
  - [$$$] -----> [$|$|$]
- Multi-Tenancy
  - Virtually dedicated resources
- Data Locked-in
  - Collaborations can only be achieved through desktop.
  - E.g.: create/edit Word documents in Dropbox.
- A suitable fine-grained cross-tenant access control model is essential



Source: http://blog.box.com/2011/06/box-and-google-docs-accelerating-the-cloud-workforce/

Industry Solutions

- Microsoft and IBM: Fine-grained data sharing in SaaS using DB schema
  - Only feasible in DB
- NASA: RBAC + OpenStack (Nebula)
  - Lacks ability to support multi-org collaborations
- Salesforce (Force.com): Single Sign-On + SAML
  - Focus on authentication and simple authorization
  - Heavy management of certificates

Source: http://msdn.microsoft.com/en-us/library/aa479086.aspx
http://nebula.nasa.gov/blog/2010/06/03/nebulas-implementation-role-based-access-control-rbac/
http://wiki.developerforce.com/page/Single_Sign-On_with_SAML_on_Force.com

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Motivation

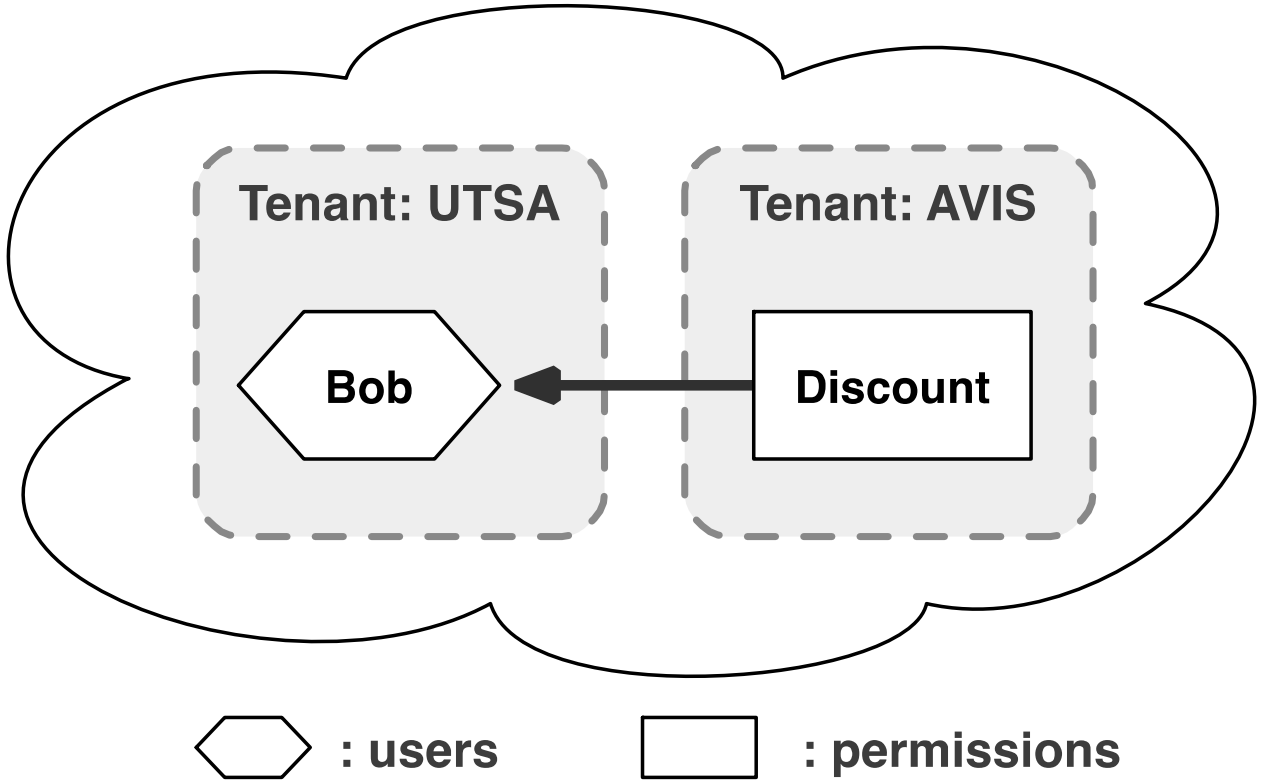

Figure 1. A car renting example of cross-tenant accesses

On-Demand Self-Service

- Centralized facility
  - Resource pool
- Multi-tenancy
  - Unilateral and automatic provisioning as needed
  - Dynamically assigned virtual resources
- Temporary users and tenants

Scope and Assumptions

- Standardized APIs
  - Cross-tenant accesses are functionally available
- Authenticated Users
- Removable assumptions:
  - One Cloud Service
    - But extensible to multi-cloud
  - Two Tenant Trust (rather than federation)
  - Unidirectional Trust Relations (like follow in Twitter)
  - Unilateral Trust Relations (trustor or trustee)

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Tenant Trust Relations

- Tenant Trust (*TT*) relation is not partial order
- It is
  - Reflexive: $A \trianglelefteq A$
  - But not transitive: $A \trianglelefteq B \wedge B \trianglelefteq C \not\Rightarrow A \trianglelefteq C$
  - Neither symmetric: $A \trianglelefteq B \not\Rightarrow B \trianglelefteq A$
  - Nor anti-symmetric: $A \trianglelefteq B \wedge B \trianglelefteq A \not\Rightarrow A \equiv B$

Trust Types

- Four potential trust types:
  - Type-α: trustor can give access to trustee.
  - Type-β: trustee can give access to trustor.
  - Type-γ: trustee can take access from trustor.
  - ~~Type-δ: trustor can take access from trustee.~~
    - No meaningful use case, since the trustor holds all the control of the cross-tenant assignments of the trustee's permissions.

Formalized CTTM Model

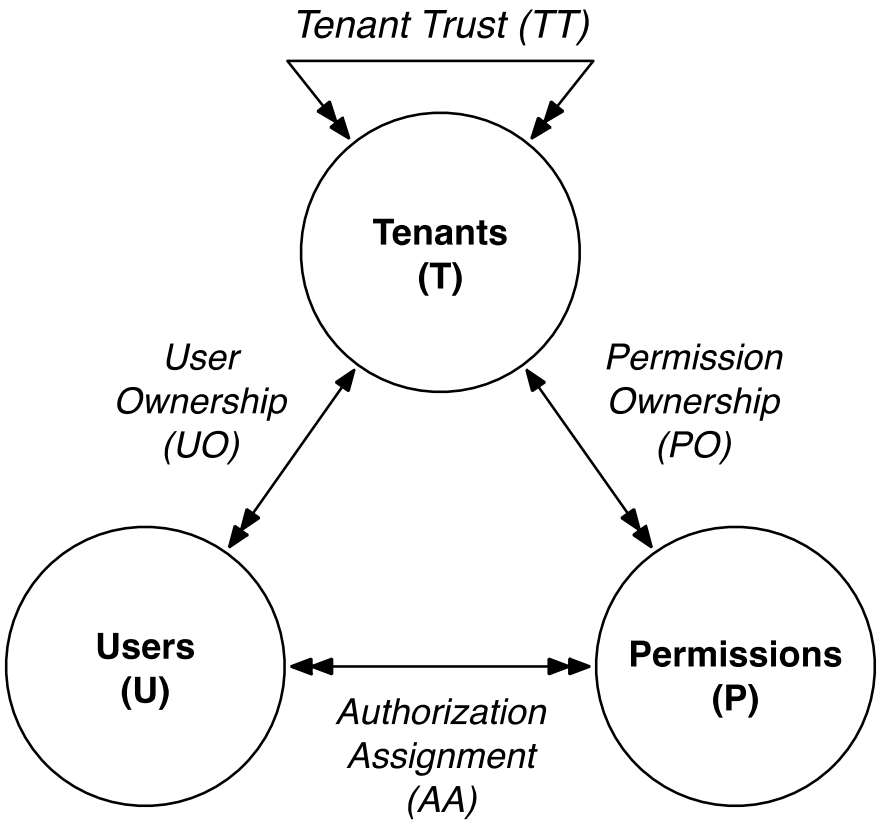

Figure 2. Cross-Tenant Trust Management model

CTTM Authz. Assignments

- AA $\subseteq$ U $\times$ P , a many-to-many user-to-permission assignment relation, also written as "$\leftarrow$", requiring that u $\leftarrow$ p only if
  permOwner(p) $\equiv$ userOwner(u) $\vee$
  permOwner(p) $\trianglelefteq_{\alpha}$ userOwner(u) $\vee$
  userOwner(u) $\trianglelefteq_{\beta}$ permOwner(p) $\vee$
  permOwner(p) $\trianglelefteq_{\gamma}$ userOwner(u),
  where only one of the $\trianglelefteq$ requirements can apply depending on the nature of *TT*.
- Example: Bob@UTSA $\leftarrow$ discount%AVIS

Role-Based CTTM

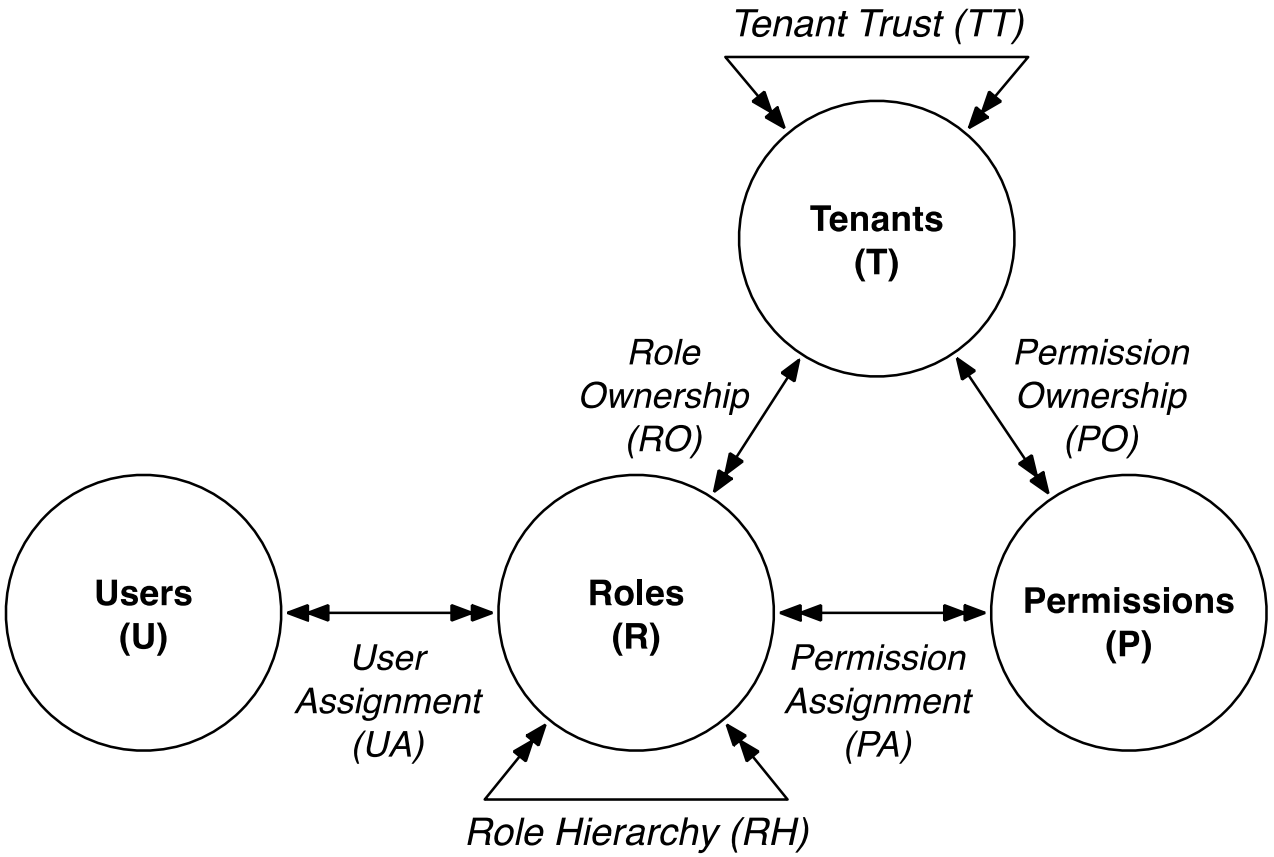

Figure 3. Role-Based Cross-Tenant Trust Management model

RB-CTTM Authz. Assignments

- UA $\subseteq$ U $\times$ R, is a many-to-many user-to-role assignment relation;
- PA $\subseteq$ P $\times$ R, is a many-to-many permission-to-role assignment relation requiring that $(p, r) \in PA$ only if
  $permOwner(p) \equiv roleOwner(r)$ $\vee$
  $permOwner(p) \trianglelefteq_{\alpha} roleOwner(r)$ $\vee$
  $roleOwner(r) \trianglelefteq_{\beta} permOwner(p)$ $\vee$
  $permOwner(p) \trianglelefteq_{\gamma} roleOwner(r)$,
  where only one of the $\trianglelefteq$ requirements can apply depending on the nature of TT;

RB-CTTM Authz. Assignments (contd.)

- RH $\subseteq$ R $\times$ R, is a partial order on R called role hierarchy or role dominance relation, also written as "$\geq$", requiring that r2 $\geq$ r1 only if
  roleOwner(r1) $\equiv$ roleOwner(r2) $\vee$
  roleOwner (r1) $\trianglelefteq_{\alpha}$ roleOwner(r2) $\vee$
  roleOwner (r2) $\trianglelefteq_{\beta}$ roleOwner (r1) $\vee$
  roleOwner (r1) $\trianglelefteq_{\gamma}$ roleOwner(r2),
  where only one of the $\trianglelefteq$ requirements can apply depending on the nature of TT;

Feasibility in the Cloud

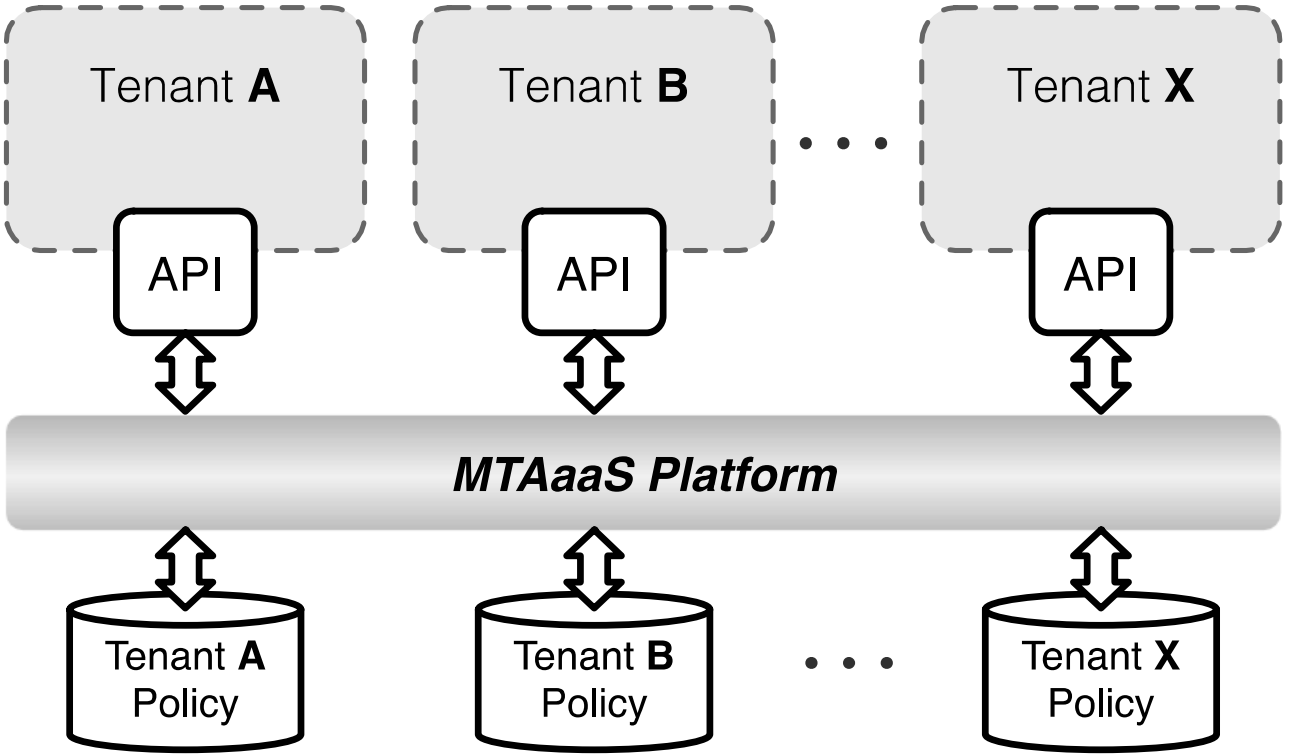

Figure 4. Multi-Tenant Authorization as a Service (MTAaaS) Architecture

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Related Work

- RBAC
  - CBAC, GB-RBAC, ROBAC (e.g.: player transfer in NBA)
  - Require central authority managing collaborations
- Delegation Models
  - dRBAC and PBDM (e.g.: allowing subleasing)
  - Lacks agility (which the cloud requires)
- Grids
  - CAS, VOMS, PERMIS
  - Absence of centralized facility and homogeneous architecture (which the cloud has)

Related Work (Contd.)

- Role-based Trust
  - RT (Type-α trust relation)
  - MTAS (Type-β trust relation)
  - MT-RBAC (Type-γ trust relation)
  - Suits the cloud (out-sourcing trust)

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Conclusion

- Needs of cross-tenant access control
- On-demand self-service model
- Tenant trust relation and types
- CTTM and RB-CTTM models
  - Formalization
  - Feasibility in the cloud
- Mapping to related work
  - RT, MTAS and MT-RBAC

Future Work

- Other models compatible with MTAaaS platform
- Implementation MTAaaS in OpenStack


Q & A


Thank You!